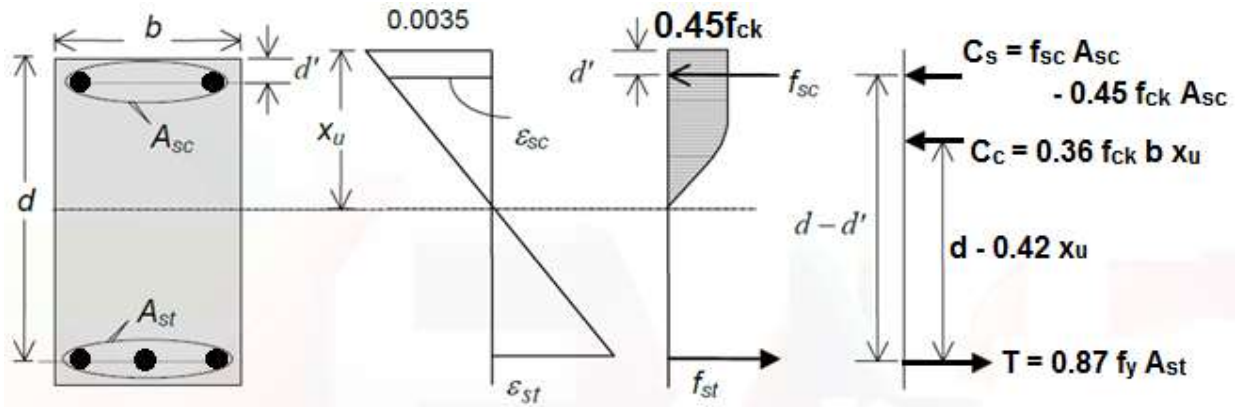
➢ Analysis of Doubly reinforced Beams

Doubly reinforced beams are resorted to under following circumstances:

- Where cross sectional dimensions of the beam are restricted, due to architectural or other considerations
- Where singly reinforced beam is inadequate to resist moment
- Where reversal of moments is likely to occur

Presence of compression reinforcement helps reduce long-term deflection & cracking due to shrinkage & creep.



The distribution of stress and strain across the section is shown above. From this, the following may be deduced.

Let f_{sc} = stress in compression steel

A_{sc} = area of compression steel

d' = distance between centroid of compression steel to the extreme compression fibre

- Compressive force in Concrete $C_c = 0.36\ f_{ck}\ b\ x_u$
- Compressive force in steel $C_s = f_{sc}\ A_{sc} - 0.45\ f_{ck}\ A_{sc}$
- Tensile force in steel $T = 0.87\ f_y\ A_{st}$
- Depth of neutral axis X_u is obtained from $C_c + C_s = T$, as:

$$X_u = \frac{0.87\ f_y\ A_{st} - f_{sc} A_{sc} + 0.45\ f_{ck} A_{sc}}{0.36\ f_{ck}\ b\ X_u}$$

- In the above equation, f_{sc} is taken from Stress-Strain curve of steel for the corresponding value of strain ε_{sc} computed from:

$$\varepsilon_{sc} = 0.0035 \times \left(1 - d'/x_u\right)$$

- In general practice, the value of ratio (d'/d) ranges between 0.05 to 0.20.
- Value of f_{sc} is given by:
  - = 0.87 f_y = 217.5 N/mm2, for Fe250 grade steel

- If Fe415 or Fe500 is used, the compression steel would not have yielded as Fe250. Hence, f_{sc} is obtained from ε_{sc}.

- Value of f_{sc} for a balanced section is given below (in N/mm2)

Grade of steel	d'/d			
	0.05	0.10	0.15	0.20
Fe 250	217.5	217.5	217.5	217.5
Fe 415	355	353	342	329
Fe 500	424	412	395	370

- Ultimate moment of resistance of this section is:

$$M_u = C_c (d - 0.42 X_u) + C_s (d - d')$$